

## The 2009 RWDC State Challenge

Design an economical twin-engine jet airplane that meets assigned cruise speed and stall speed requirements. The importance of these two performance characteristics is reflected in the scoring procedure for the Challenge. **The fuel burn rate result will contribute up to a maximum of 70 of the 100 points available toward the final team score. Failure to meet the stall speed requirement of the Challenge will result in a deduction of 20 points from the final team score.**

| Design Variables   |   |
|--|---|
| <b>Wing Platform</b>   | Sweep, taper, winglets, etc.  |
| <b>Airfoil Section</b>   | Airfoil can be constant, several sections, smoothly varying, etc  |
| <b>Aircraft weight as a function of the wing area</b>  | $W = 15000 \text{ lbs} + S \times 7.7 \text{ lbs/sq-ft} + S_{\text{other}} \times 5.0 \text{ lbs/sq-ft}$ where S is the planform area of the wing, and $S_{\text{other}}$ is the additional planform of winglets and/or high lift devices |
| Design Requirements  |   |
| Stall speed must be less than 130 kts (freestream velocity at 15,500 ft, Standard Atmosphere) to ensure adequate landing performance.        |   |
| High lift devices (flaps, slats, etc) to reduce stall speed are allowed but not required and must consider additional complexity and weight. |   |
| Wing span may not be greater than 64 ft, a typical value for business class jet aircraft.  |   |

## Constants

Cruise speed shall be 400 kts (freestream velocity at 37,000 ft, Standard Atmosphere).

Assume constant weight during the flight as given in the formula above. This includes aircraft structure, crew, passengers, cargo, and fuel.

## Assumptions

Assume a rigid wing and fuselage.

Ignore the effects of control surface and tail sizing to match the wing design.

## Fuel Burn Rate Calculation

Design an airplane that meets the design requirements with lowest possible drag in cruise.

Required thrust in cruise equals drag

Fuel burn rate (fuel flow) for the each engine is given by:

Fuel burn rate or Fuel flow = SFC x Thrust (lb/h)

Where:

SFC = 0.68 lb/(lbf h) (Specific Fuel Consumption per engine)

And:

lb is pounds of fuel

lbf is engine thrust in pounds

h is time (hour)

## Design Sequence

|  |   |
|--|---|
| <b>Modify the wing design (1st time around, start with the design in the tutorial)</b>   |   |
| <b>Solve a batch run of varying Angles of Attack (<math>\alpha</math>) at cruise conditions</b>  | $V_x = (\cos(\alpha))(400 \text{ kts})$ $V_y = (\sin(\alpha))(400 \text{ kts})$   |
| <b>Find the range of <math>\alpha</math> where Lift (Component of Force perpendicular to the free stream flow) is approximately equal to Weight and repeat the batch run for smaller steps of <math>\alpha</math> in that range.</b> |   |
| <b>Find the Drag (Component of Force parallel to the free stream flow) acting on the aircraft at the cruise Angle of Attack.</b>   |   |
| <b>Now, check to see if the airplane meets stall speed requirements:</b>   | <p>Solve a batch run of varying <math>\alpha</math> at landing conditions (15,500 ft, 130 kts freestream velocity).</p> <p>Find the range of <math>\alpha</math> where Lift <math>\approx</math> Weight and repeat the batch run for smaller steps of <math>\alpha</math> in that range.</p> <p>Verify that the airplane is capable of producing the lift required to meet the stall requirement.</p> |
| <b>When a design with low cruise drag is established, calculate Fuel Burn Rate required.</b>   |   |